

GROWTH PATTERN OF MANGROVES IN THE GULF OF KUTCH¹

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(With three text-figures)

Key words: Mangroves, Gulf of Kutch, *Avicennia marina*, growth pattern

In the past, mangroves were tall, over 14 m in height in Gujarat State. Eleven core species were recorded in the literature, but during an extensive survey of the tidal forests of Gujarat from 1994 to 1999, only eight species, with the dominant *Avicennia marina*, have been encountered. Most mangroves are now shrubby, with an average height of 2 m, while *A. marina* attains moderate height along creeks and towards the sea. Heights of dominant trees in the Gulf of Kutch were normally 5 to 7 m, rarely exceeding 9 m in western mangroves. Stump and stem analysis of *A. marina* on Pirotan Islands (Marine National Park, Jamnagar) and in western mangroves (Kutch), revealed that four growth rings were formed annually, as against two rings in trees, especially conifers.

Extreme summer and winter are not suitable for photosynthesis of *A. marina* in the Gulf of Kutch, and are non-growth periods. Studies in other parts of the world indicate that photosynthesis of *A. marina* ceases below 13 °C and above 35 °C, with peak production between 20 °C and 27 °C. Two nongrowth periods alternating with the growth periods explain the formation of more than two rings a year.

INTRODUCTION

The Gulf of Kutch (22°15' N to 23°40' N and 68°20' E to 70°40' E), Gujarat State, is located in western India. Jamnagar and Rajkot districts of Saurashtra to the south and Kutch district in the north constitute the boundary of the Gulf. The Gulf has an area of 7,350 sq. km, the east-west length is about 170 km and width 175 km at the mouth. The southern part of the Gulf has a network of 42 islands (*bets*) with coral reefs and rich marine life.

The average annual rainfall in the region ranges from 400 to 600 mm, with about 14 rainy days, mostly from the SW monsoon, which breaks over Saurashtra and Kutch in the end of June and continues to the end of September. Air temperature ranges from 7.8 °C in January to 44.8 °C in May. The water temperature generally varies from 15 °C to 35 °C. However, local increase above 35 °C is recorded in summer in

isolated water pools in the intertidal area. Evapo-transpiration in Kutch is very high and annual ratio of precipitation to evapo-transpiration ranges between 0.3 and 0.5. The humidity in Kutch varies from 50% during November-December to 80% during SW monsoon (Singh *et al.* 1999). There is no perennial river in Saurashtra and Kutch, and discharge of rainwater through seasonal monsoon rivers is reduced due to the construction of dams.

Tide amplitude in the Gulf is recorded varying from 3.0 m to 6.0 m. Water salinity in the mangrove creek normally varies from 37 ppt to 44 ppt and still higher salinity is recorded in summer in pools of water in the hyper-saline zone. Low rainfall, extreme temperature, salinity and tide amplitude are limiting factors for the development of mangroves (Singh 1999). The pH value of creek water ranges between 7.7 and 9.1 in western mangroves (Singh *et al.* 1999). Average pH value of the mangrove soil at Pirotan was 8.4 (8.1 to 8.9). Average organic carbon was 0.43%, whereas available phosphorus and potash content was 33.3 kg/ha and 4.0 kg/ha respectively (Singh 1999).

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Mangroves in Gujarat: Gujarat State has notified a total area of 1,324 sq. km in Kutch, Jamnagar and Rajkot districts in the Gulf of Kutch as mangrove forests, locally called *Cher*. Using remote sensing technology, the Forest Survey of India (FSI), Dehra Dun in 1997 and 1999, estimated a mangrove cover of about 991 and 1,031 sq. km respectively in Gujarat, second only to the Sunderbans in West Bengal. The Gujarat Ecological Education and Research (GEER) Foundation, Gandhinagar made an independent study in 1999 using IRS LISS-111 data of 1998, and interpreted forest cover on a scale of 1:50,000. This provided an accurate estimate of 938.4 sq. km (874.4 sq. km in the Gulf of Kutch) mangrove cover. Western mangroves in Abdasa and Lakhpat taluka, known as Indian deltaic mangroves, are the largest tidal forests in Gujarat. Part of the mangroves in and around Kori creek were destroyed by the cyclone that hit Gujarat and the coast of Pakistan in May 1999.

Floral diversity and height of mangroves decreases as one moves away from the equatorial region, and hence diversity of mangroves in Gujarat is poorer than in other mangroves of the country. Thirteen core mangrove species have been recorded on the western coast of India. Eleven species, belonging to seven genera and five families were recorded in Gujarat (Chavan 1985, Kothari 1991), nine of them in the Gulf of Kutch. *Avicennia officinalis*, *A. marina*, *A. alba*, *Aegiceras corniculatum*, *Ceriops tagal*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Sonneratia apetala*, *Acanthus ilicifolius*, *R. apiculata* and *B. cylindrica* were species recorded in Gujarat. Singh (1999) could record only eight species in Gujarat as *R. apiculata*, *Bruguiera gymnorrhiza* and *B. cylindrica* were not encountered in the two years study. At present, only seven core species of mangroves grow in the Gulf of Kutch.

Avicennia marina dominates the forests of Gujarat, constituting the majority of mangrove trees in the State, which are shrubby with low

height, but *A. marina* attains good height along the creek and seaward.

METHODS

Growth pattern of mangroves in the Gulf of Kutch was not studied in the past, except that the height of mangroves was recorded in some areas. To understand tree development pattern at good sites in the Gulf, the literature including records of the Forest Department were studied, and height of trees was measured at a few sites while the author was serving as Conservator of Forests, Marine National Park. Tree diameter and height relationship, and heights and corresponding diameters of *Avicennia marina* were recorded on Pirotan, its neighbouring *bets* and in western mangroves in Kutch. Studies on *A. marina* by the Gujarat Institute of Desert Ecology (GUIDE), Bhuj on western mangroves were also consulted (Singh *et al.* 1999).

Girth at breast height (gbh) and height of *Avicennia* trees were measured in landlocked mangroves at Shravan Kavadiya to understand growth pattern in the past. While carrying out this exercise, distinct growth rings were observed on a tree stump. Thus providing an idea to conduct stump and stem analysis of trees to understand growth pattern. Stem and stump analysis was hence, done at Pirotan Island and in western mangroves near Siyadinar. 15 trees at Pirotan and 5 trees in western mangroves were cut for this purpose. Thousands of tall trees had died in the cyclones of 1998 and 1999, only dead trees were cut, at 20 to 50 cm above ground level, depending on the tapering of the stump. Four radii were drawn on the stump and each radius was measured at intervals of 10 growth rings, and the average diameter was estimated.

RESULTS AND DISCUSSION

Mangrove trees with a height of 14 m have been recorded in the past (Chavan 1985).

Landlocked mangroves at Shraavan Kavadiya in fringes of Banni grassland are tall. This land was part of the Gulf in the historic past. A small patch of old mangroves in about 0.7 ha survived till the cyclone that occurred in June, 1998. About 36 trees with tops broken still survive on the site. The average height of dead trees measured about 18.0 m in 1999. This reveals that mangroves in the Gulf were extensive and taller than those in existing forests. Various studies indicated that geomorphological and climatic changes had made an impact on mangroves in the region.

Presently in Gujarat, mangroves are shrubs with an average height of 2 m, but they attain good height along the creek and seawards. *Rhizophora mucronata* occurs only on the islands in the Marine National Park; its average height is 3.5 m. *Ceriops tagal* and *Aegiceras corniculatum* are also shrubs about 1.2 to 1.4 m high; they occur only on the *bets* in the Park. The height of the tallest *Ceriops tagal* at Pirotan was 2.9 m. *Acanthus ilicifolius* is a shrub growing in the estuarine areas of south Gujarat. *Sonneratia apetala* occurs in the estuary of the Tapti, where trees exceed 6 m height in restricted areas.

Avicennia alba is a small tree, while *A. marina* is the tallest tree in the mangroves in Gujarat. Old trees of *A. marina* were observed in 1994, and most of them had broken tops. Their height was between 5.0 and 7.2 m on Chhad and Zindra *bet*. Good *cher* forest, regenerated after destruction of old mangroves on Pirotan and Bhensbid, had an average top height of 4.4 m (3.6 to 5.4 m) in 1994, which increased to 5.3 m (4.0 to 6.0 m) in 1999. Measurements of dominant trees at Pirotan revealed that a plantation of 1983 attained top height of 3.2 m in 15 years.

Singh (1999), conducted surveys of western mangroves at five sites (Medi creek, Laki creek, Jakhau, Mundra, Kori creek), and reported that density of trees (height of 75 cm) ranged from the lowest 792 trees/ha at Laki to a

maximum of 1900 trees/ha at Kori creek. Tree height in the area ranged from 0.75 to 10.0 m. Trees at Medi post were taller, with a mean height of 3.7 m and shorter at Jakhau with a mean height of 2.2 m. In all the five stations, heights in the range of 1.6 to 3.0 m were greater in number followed by 1.0 to 1.5 and 3.0 to 4.5 m classes.

The tallest trees with heights of about 10.0 m were recorded at Carissod creek. Trees up to 9.0 m were measured in Kav creek in the forest of Medi post. Many trees in the height class of 6.0 to 7.5 m were measured in Kori, Medi and Laki creeks. At Mundra and Jakhau, tree height did not exceed 6.0 m. The maximum number of trees above 6.0 m was recorded in the forest of Medi post. Mean gbh in the western mangroves was estimated from 31 cm at Mundra to 37 cm at Medi. Maximum and minimum gbh recorded was 15 cm at Navinal creek and 2.25 m at Laki creek. Trees with gbh of 21 to 40 cm predominated at all sites, followed by the 41 to 60 cm class (Singh *et al.*, 1999). Average height and gbh of 17 tall (dominant) trees in Jakhau forest were estimated at 5.3 m (4.0 and 6.9 m) and 43.6 cm (27 and 66 cm), respectively (Singh 1999).

Stump and Stem Analysis: As mentioned earlier, growth rings on stumps of *Avicennia marina* are as distinct as those of any coniferous tree growing in the temperate region. The author, along with the Conservator of Forests, Marine National Park, his staff, and scientists of GEER Foundation, initiated an exercise on one of the *bets* (Pirotan) in the Park. On small stumps, number of rings (light or dark) was exceptionally high, which made the investigators sceptical. Trees were cut in an area which was regenerated after 1982 to confirm findings. There were no mangroves on the site before the plantation in 1983. Study revealed that the number of growth rings (dark or light) was almost double the age of plantation. This was confirmed from other areas also. This finding appeared to have no explanation. Local watchmen and fishermen

informed us that the *cher* forests remain green and luxuriant during monsoon and in late winter or early summer. They become dull and pale green at the peak of winter and summer. This probably means that there are two good growth periods in a year, with two non-growth periods. Mangroves in similar climatic conditions in Australia and America respond to temperature stress by decreasing their structural complexity i.e. decreased tree height, leaf area index, leaf size and increased tree density (Lugo and Zucca, 1977). Mangroves growing in the environment prevailing in the Gulf are less tolerant to low temperature. McMillan (1971) reported that high water temperature could also be a limiting factor. Hutching and Saenger (1987) concluded in their study that for Australian mangrove species, growth ceases below 15 °C with peak production occurring between 20 °C and 27 °C. *Avicennia marina*, classed by them as a cool temperate species, commences leaf production above 12 °C with peak production at around 20 °C. MacNae (1963), found that *A. marina* occurs in southern Africa in the areas where mean air temperature does not fall below 13 °C. Various studies have shown that for most mangrove species, photosynthesis declines sharply above 35 °C (Pernetta, 1993). In the Gulf of Kutch, temperature difference is very high. In summer, air temperature increases above 40 °C and soil temperature above 35 °C. Thus, growth (photosynthesis) of *Avicennia* species in the Gulf remains very low during summer (May-June) due to high temperature, increased salinity and high water current and also during extreme winter, (December-January) due to low temperature. On the basis of the above, it appears that there are four periods in a year differentiating distinct growth seasons.

The above analysis explains that there are two non-growth periods in mangroves in the Gulf, i.e. extreme summer and winter. This finding is not conclusive, but forms the basis for further study on the growth pattern of *A. marina*

in the subtropical region. It is assumed here that four growth rings are formed annually. The growth pattern of *A. marina* on the basis of stump and stem analysis is discussed below.

Data on 15 trees at Pirotan and 5 trees in western mangroves have been analysed. Trees were cut at a height of 20 to 50 cm above ground level, depending on stem form near the ground. The growth pattern of *Avicennia* trees at good sites along the creek or seawards is given in Tables 1, 2 and 3, and Figs 1, 2 and 3. These show that *Avicennia marina* attains 4.9 m height and about 31 cm girth at stump in 20 years at Pirotan. The growth pattern has been extrapolated up to 22 years tree age, but could not be done beyond this due to non-availability of old trees in the area. This analysis is site and situation specific and may differ from other areas.

Mangroves in Jakhau (Siyadinar) are some of the good tidal forests in Kutch. Large numbers of big trees died in the cyclone in May 1999. Five dead trees were cut to carry out stump analysis. Two dark and two light rings were considered as one year's growth. Trees were cut at 50 cm from the ground and rings were counted along four radii on each stump. Table 2 gives the results of graphic analysis of average age and corresponding diameter. Stump analysis revealed that *A. marina* has an average diameter of 11.0 cm at stump (50 cm above ground) in 25 years and 22.5 cm in 50 years near the creek.

CONCLUSION

The Gulf of Kutch is not a true tropical region, and climatic conditions are not ideal for mangroves as in the Sundarbans and the Andaman and Nicobar Islands. Most of the mangroves in the Gulf of Kutch and other parts of Gujarat are shrubby, but *A. marina* attains moderate height at good sites near the creek and seawards. The top canopy of mangrove trees is usually damaged as a result of high winds and cyclones. Although mangroves in the Gulf were

GROWTH PATTERN OF MANGROVES

TABLE 1
GROWTH PATTERN OF
AVICENNIA

Age in years	Girth at stump (cm)
2	NA
4	5.0
6	6.5
8	9.5
10	15.5
12	21.0
14	24.0
16	26.5
18	29.5
20	31.0
22	32.0

TABLE 2
GROWTH PATTERN OF
AVICENNIA

Age in years	Height (cm)
2	60
4	90
6	120
8	180
10	270
12	350
14	390
16	430
18	470
20	490
22	510

TABLE 3
GROWTH PATTERN OF
AVICENNIA

Age in years	Ave. diameter at stump (cm)
5	2.0
10	4.1
15	6.5
20	8.7
25	11.0
30	13.0
35	16.0
40	18.7
45	20.5
50	22.5
55	24.0
60	25.5
65	26.5

Age-height relationship at Pirotan

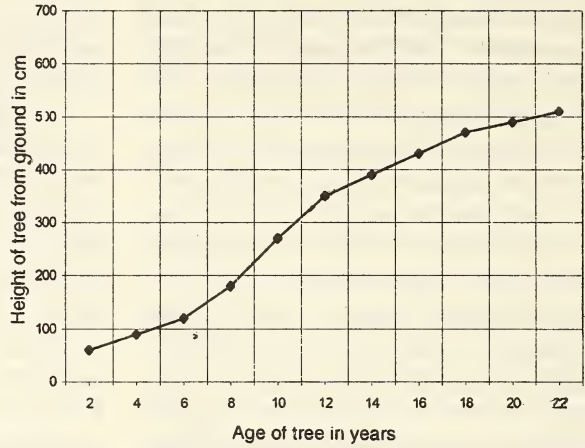


Fig. 1: Growth pattern of *Avicennia*

Girth-height relationship at Pirotan

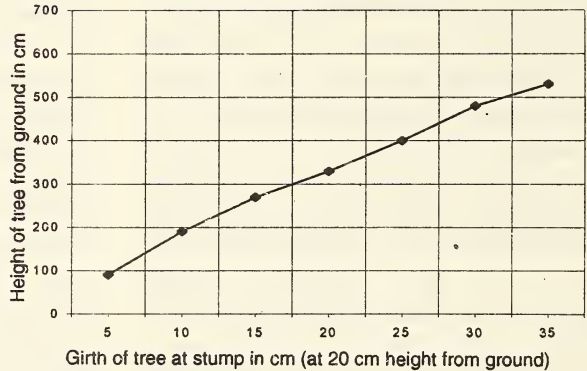


Fig. 2: Growth pattern of *Avicennia*

Age-diameter relationship in western mangroves (Kutch)

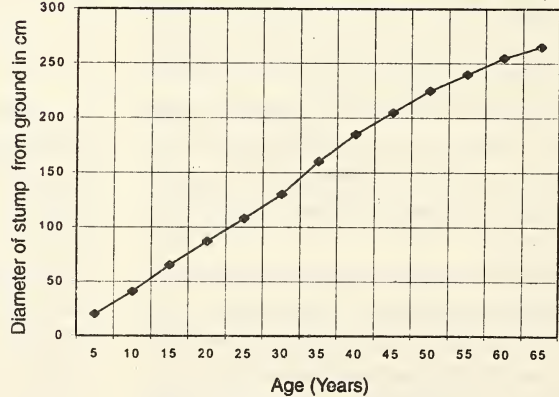


Fig. 3: Growth pattern of *Avicennia*

tall in the past, their height now rarely exceeds 9.0 m. On an average, the diameter of *A. marina* increases 0.45 cm (0.4 cm to 0.5 cm) per year at good sites in the Gulf of Kutch. This study revealed that distinct rings are formed as a result of change in temperature and other climatic conditions. Photosynthesis is at a maximum during monsoon and moderate summer, and is

low or almost absent in extreme winter and summer. Light and dark rings on stumps are certainly related to growth variation. Unlike two-ring formation in a year in most trees, especially in temperate forests, there are four growth rings in *A. marina*. Findings in this paper add to our knowledge of mangrove development in the Gulf of Kutch, laying the basis for further studies.

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